

Sewage disposal

East bay area

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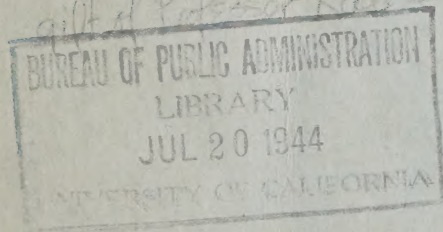
REPORT UPON
THE COLLECTION, TREATMENT AND DISPOSAL
OF SEWAGE AND INDUSTRIAL WASTES
OF THE EAST BAY CITIES

CALIFORNIA : *recommendations*



JS364:R3 East bay area
JS91: Waterfront
HV680:W2 S.F. bay

ALAMEDA	EMERYVILLE
ALBANY	OAKLAND
BERKELEY	PIEDMONT
RICHMOND	



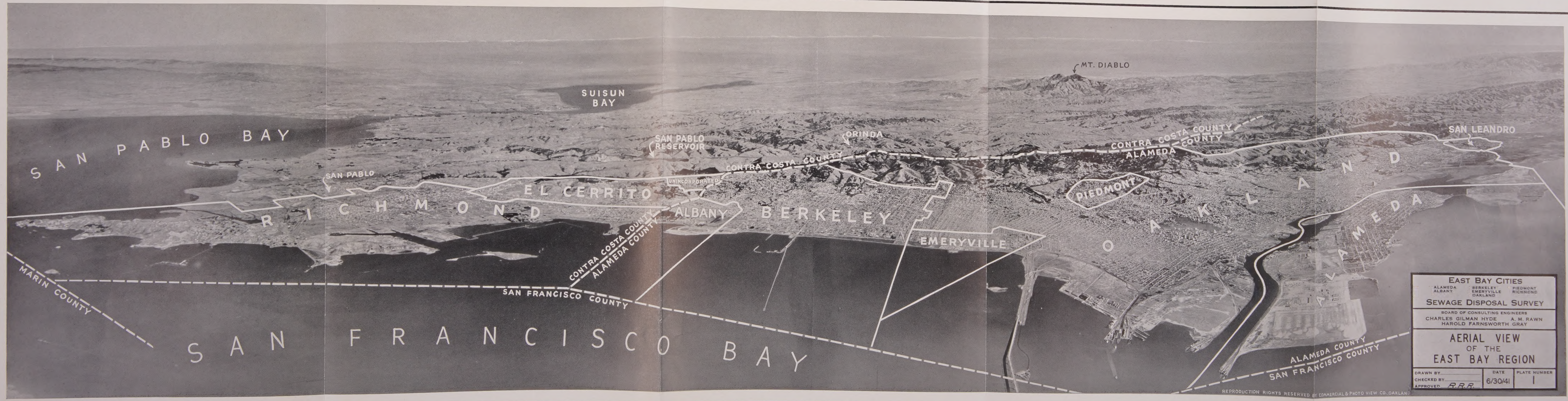
June 30, 1941

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1941

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EAST BAY CITIES
ALAMEDA ALBANY BERKELEY EMERYVILLE OAKLAND PIEDMONT RICHMOND

SEWAGE DISPOSAL SURVEY
BOARD OF CONSULTING ENGINEERS
CHARLES GILMAN HYDE A. M. RAWN
HAROLD FARNSWORTH GRAY

**AERIAL VIEW
OF THE
EAST BAY REGION**

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EAST BAY CITIES SEWAGE DISPOSAL SURVEY

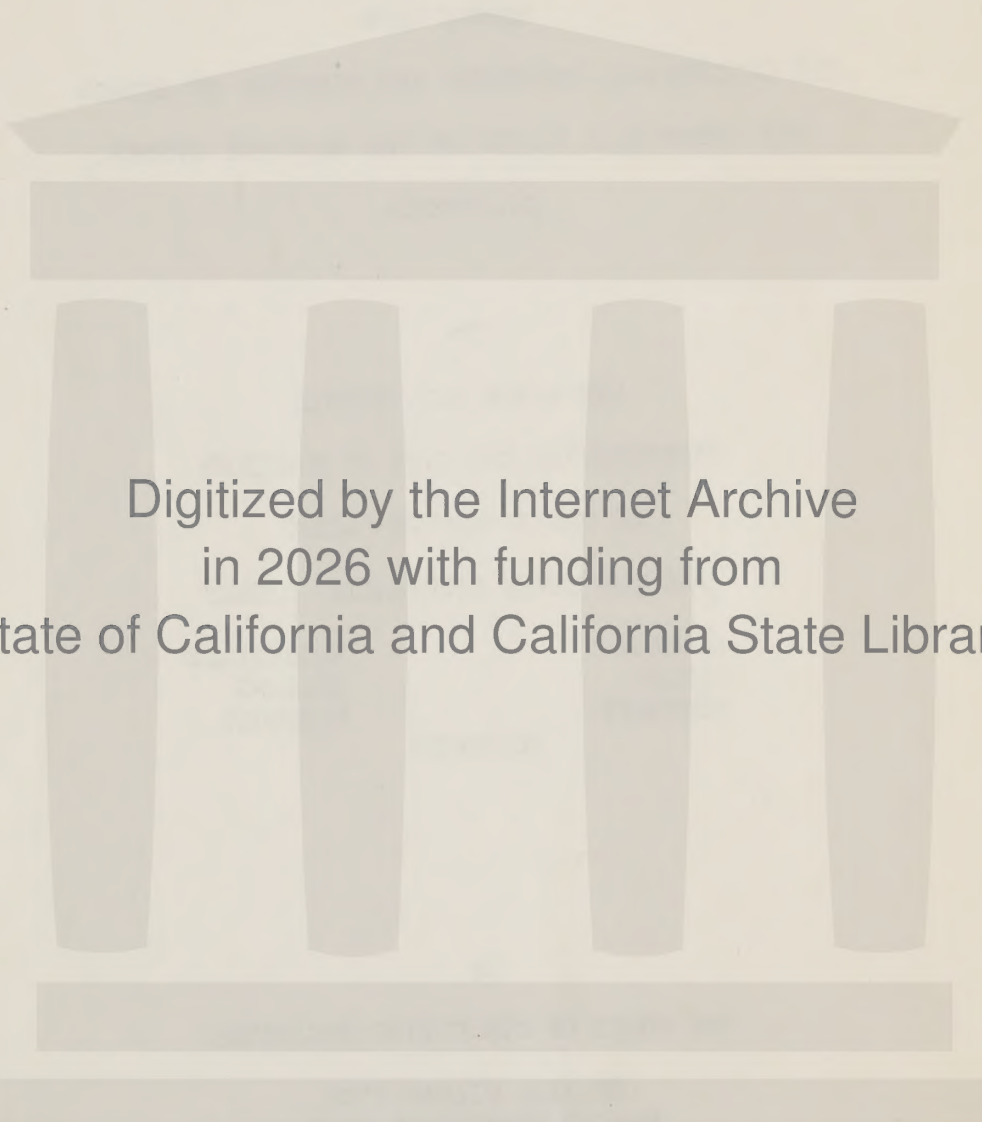
REPORT UPON
THE COLLECTION, TREATMENT AND DISPOSAL OF SEWAGE
AND INDUSTRIAL WASTES OF THE EAST BAY CITIES,
CALIFORNIA : *a recommendations*

To
THE MAYOR AND COUNCIL
REPRESENTING THE CITY OF BERKELEY
AS THE SPONSORING AGENT
FOR THE SEVEN COOPERATING CITIES
ALAMEDA EMERYVILLE
ALBANY OAKLAND
BERKELEY PIEDMONT
RICHMOND

By
THE BOARD OF CONSULTING ENGINEERS

CHARLES GILMAN HYDE
HAROLD FARNSWORTH GRAY
A. M. RAWN

JUNE 30, 1941



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TO THE MAYOR AND COUNCIL

CITY OF BERKELEY, CALIFORNIA

Gentlemen:

Under an Agreement entered into the third day of July, 1940, by and between the City of Berkeley and the undersigned as a Board of Consulting Engineers, we have the honor to submit herewith a "Report upon the Collection, Treatment and Disposal of Sewage and Industrial Wastes of the East Bay Cities, California". This Report is addressed to your Honorable Body representing the City of Berkeley as Sponsor for the group of seven co-operating cities - Alameda, Albany, Berkeley, Emeryville, Oakland, Piedmont, and Richmond - under a Contract dated June 7, 1940.

The Report complies with the specific requirements of Section II of the Agreement with the Board, in that it presents:

1. the results of investigations and analyses of all conditions affecting the problem of sewage disposal of the said cities;
2. advice as to general or particular schemes that should be adopted by said cities for disposal of the sewage thereof;
3. advice as to the proper location of intercepting sewers, pumping plants, sewage treatment works, and outfalls;
4. recommendations as to the type of sewage treatment processes which should be adopted;
5. estimates as to the cost of construction and operation (total annual costs) of sewerage and sewage disposal projects studied and recommended;
6. recommendations concerning the units into which the recommended

TO THE MAYOR AND COUNCIL

- projects may be divided and the sequence of construction thereof;
7. recommendations as to appropriate regulations affecting the use of sewers and sewerage systems, and sewage treatment and disposal works;
 8. considered opinion concerning the agency which should be responsible for the financing, design, construction and operation of the projects herein recommended, including intercepting sewers, pumping plants, sewage treatment works, and outfalls required for the disposal of the sewage of the East Bay area.

In addition to the Recommendations and Findings of the Board, the Report presents a great mass of information and data obtained by the staff of the Survey under the able direction of Mr. Raymond R. Ribal, Principal Assistant Engineer, in charge. The Board takes this opportunity to acknowledge and commend the admirable services which have made this Report possible.

It may be of interest to note that the Report contains 15 specific Recommendations, 224 Findings, 120 formal tables together with numerous summary tabulations, and 104 plates, supplemented by detailed explanation, interpretation and discussion in the body of the Report and the Appendices. It is the hope and desire of the Board and of the Survey staff that this material will prove of value in the final design and future operation of sewage and sewage treatment and disposal works.

As required under paragraph (h) of Section II and in general compliance with Section III of the Agreement, the Board has previously

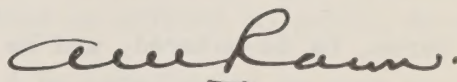
TO THE MAYOR AND COUNCIL

under date of November 1, 1940, rendered a report entitled "Report of Board of Consulting Engineers Upon Legislative Requirements for Sewage Disposal with Recommendations".

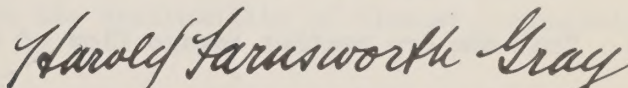
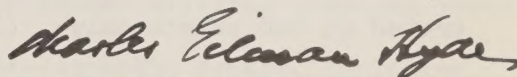
The Board of Consulting Engineers has met in thirty-five formal sessions and has devoted its best energies to the determination of a proper and economic solution of the problems which were assigned to it.

Respectfully submitted,

BOARD OF CONSULTING ENGINEERS



A. M. Rawn


Harold Farnsworth Gray, Secretary
Charles Gilman Hyde, Chairman

Dated at Berkeley, California

June 30, 1941

REPORT UPON THE COLLECTION, TREATMENT AND DISPOSAL
OF SEWAGE AND INDUSTRIAL WASTES OF THE EAST BAY CITIES, CALIFORNIA

RECOMMENDATIONS

The Board of Consulting Engineers recommends:

1. That the natural potential advantages of the great mass of water in San Francisco Bay be practically utilized through the disposal by dilution therein of partially (primary) treated rather than completely (final) treated sewage.
2. That the sludge removed from the sewage by so-called primary treatment be digested in suitable tanks maintained at favorable temperatures, be de-watered, and be disposed of as fertilizer on public parks or by sale.
3. That the dry weather sewage flow of the East Bay Cities and of all areas naturally tributary thereto by reason of topography be concentrated at two points only: (1) in the vicinity of the intersection of Standard Avenue and Castro Street, Richmond, (Project A); (2) in the vicinity of Twenty-second and Peralta Streets, Oakland, (Project K).
4. That provision be made in accordance with Project A for the partial or primary treatment and disposal of the dry weather flow of the sewage of Richmond, of the San Pablo Sanitary District, of a portion (25 per cent) of the Stege Sanitary District, and of areas which are likely to be developed in the Wildcat Creek and San Pablo drainage areas.
5. That provision be made in accordance with Project K for the partial or primary treatment and disposal of the dry weather flow of the sewage of a portion (75 per cent) of the Stege Sanitary District and of Albany, Berkeley, Emeryville, Oakland, Piedmont, and Alameda, together with

certain areas, as yet unincorporated, in Contra Costa County; e.g., the Kensington district.

6. That the partially treated sewage of Richmond and tributary areas be discharged into deep water off Castro Point, Richmond.
7. That the partially treated sewage of the cities and districts named in Item 5 be discharged into deep water off the outer end of the Key System pier, Oakland.
8. That the works comprehended by Project K be constructed without delay in order that the foul conditions along the Berkeley-Emerlyville-Oakland waterfront, and in the Inner Harbor, Tidal Canal and San Leandro Bay may be eliminated and no longer constitute an affront to public decency.
9. That the works comprehended by Project A be constructed as soon as public opinion can be aroused to the desirability of cleaner, unpolluted shores and harbors.
10. That a program be at once developed whereunder existing combined sewerage systems be systematically separated--domestic sewage, including industrial wastes and storm or rain waters being put into independent channels insofar as it is practicable and economical to do so--and the dry weather flows conveyed to the intercepting sewers provided under the recommended Projects A and K.
11. That more drastic ordinances be enacted and better supervision be provided to improve the character of construction of house drains and other connections with the sewers.
12. That a program of repair and reconstruction be inaugurated throughout the East Bay area aimed at the reduction of the excessive, unjustifiable amounts of ground water (infiltration) entering the sewers.
13. That lands for pumping station and treatment plant sites in accordance with Projects A and K, herein recommended, be immediately acquired while

the opportunity still exists at prices which may not yet have become exorbitant.

14. That the construction and operation of the recommended sewerage, sewage treatment and disposal works be performed by the East Bay Municipal Utility District for the reason that its administrative and engineering organization, with few additions to its technical staff, is exceedingly capable and well equipped to execute these functions.
15. That 40-year serial bonds, preferably general obligation bonds, carrying the lowest obtainable rate of interest, be issued to provide construction funds.

REPORT UPON THE COLLECTION, TREATMENT AND DISPOSAL
OF SEWAGE AND INDUSTRIAL WASTES OF THE EAST BAY CITIES, CALIFORNIA

FINDINGS

The Board of Consulting Engineers reports the following FINDINGS as the result of its own studies and deliberations and a review of the great mass of information developed by the Survey staff:

Capacity of San Francisco Bay Waters to Dispose of Sewage.

1. By virtue of its vast tidal prism, amounting to some 2,900,000 acre-feet (940,000 million gallons) per 24 hours, and because of the enormous weight of dissolved oxygen contained therein, the potential capacity of the San Francisco Bay system to receive and innocuously dispose of sewage, expressed in terms of contributory population, is of the order of from 200 to 300 million persons, according to the criteria employed; provided, of course, that the sewage is intimately mixed with the Bay waters.
2. The total average daily supply of dissolved oxygen naturally contained in the tidal prism referred to in Item 1, supplemented through re-aeration and by other sources, is possibly in the region of 35,000,000 pounds.
3. For that section of San Francisco Bay, proper, which lies between Point San Pablo and Hunters Point or Bay Farm Island, the average daily tidal prism is perhaps 510,000 acre-feet (170,000 million gallons) and its potential capacity to receive and innocuously dispose of sewage, reckoned in terms of contributory population, is of the order of 35 to 50 million persons, under the limitations stated in Item 1.

4. The total average daily supply of dissolved oxygen naturally contained in the tidal prism of San Francisco Bay, as described in Item 3, supplemented through re-aeration and by other sources, is possibly in the neighborhood of 6,000,000 pounds.
5. The computed general average daily oxygen (biochemical, 5-day, 20°C) demand of the estimated general average daily flow of sewage from the East Bay area, as considered herein, is 84,000 pounds for the year 1940 and 145,000 pounds for the year 1965.

Present Condition of East Bay Shores and Shore Waters.

6. The East Bay Cities, by reason of the lack of any program of sewage treatment and proper disposal methods, have rankly abused the extraordinary opportunities available for an economical and effective disposal of sewage or treated effluents by dilution in the waters of San Francisco Bay.
7. Because of this bad practice the shores and shore waters of the East Bay Cities have become obnoxiously and notoriously foul and an affront to civic pride and common decency.
8. The foul conditions above noted have rendered the shores and shore waters hardly utilizable for recreational uses (boating, fishing, and the like); completely unsuitable for bathing; and a handicap to industrial development and shipping.
9. With the construction of the San Francisco-Oakland Bay Bridge and the East Shore Highway running north to Richmond, great numbers of people have been made uncomfortably aware of the foul conditions along the Berkeley-Emerlyville-Oakland waterfront and are demanding an abatement of the conditions which are universally regarded as a nuisance.

10. When the new East Shore Highway running south to San Jose is constructed, travellers upon this highway will be similarly affronted and offended by the equally foul conditions on the San Leandro Bay marshes, particularly between the lower ends of Fiftieth and Ninety-second Avenues.

Nature of the Local Sewage Disposal Problem.

11. The problem of sewerage and sewage treatment and disposal facing the East Bay Cities must frankly be admitted to be one of aesthetics, primarily, rather than one definitely concerned with the public health, except perhaps indirectly.

Many-Purpose Value of Bay Shores and Waters.

12. San Francisco Bay along the waterfront of the East Bay Cities, if its shores and shore waters were clean and unpolluted, would afford much better facilities and opportunities than now exist or are apparent for the development of recreation and industry, and in some places, of housing.

Required Degree or Extent of Sewage Treatment.

13. The oxidizing capacity of the Bay waters is so great that if properly utilized it can and should supplant all refined processes of sewage treatment.
14. Therefore, partial or so-called primary treatment of the sewage of the East Bay Cities, involving short-period subsidence, grease removal, and sludge digestion and de-watering, represents the maximum degree of treatment which local conditions demand, provided the naturally available opportunities are duly capitalized.
15. Good conditions for the disposal of a partially treated (primary)

effluent, in terms of depth and strong currents, are to be found at distances from the shore line which can be readily reached at a reasonable cost.

16. An elaborate investigation of all of the possibilities which have been made apparent by long and careful study has demonstrated that, if the natural advantages of San Francisco Bay as related to the dilution, diffusion and oxidation of sewage are utilized, the most feasible and economical projects are those involving the disposal by dilution of partially treated (primary) effluent.

Recommended Projects--Projects A and K.

17. Holding these facts and conditions in review, the Survey has found that the most rational and economic solution of the problem of collecting, treating and disposing of the dry weather flow of sewage and industrial wastes (together with a proper allowance for infiltration) of the entire East Bay area is represented by a combination of two projects, designated herein as Projects A and K.
18. Project A, as proposed, will provide for the partial or primary treatment and disposal of the sewage of Richmond, of the San Pablo Sanitary District, of a portion (25 per cent) of the Stege Sanitary District, and of areas which are likely to be developed in the Wildcat Creek and San Pablo Creek drainage areas.
19. Project K, as proposed, will provide for the partial or primary treatment and disposal of the sewage of a portion (75 per cent) of the Stege Sanitary District, and of Albany, Berkeley, Emeryville, Oakland, Piedmont, and Alameda, together with certain areas, not yet incorporated, in Contra Costa County; e.g., the Kensington district.

20. Under Project A the partially treated sewage will be discharged into deep water off Castro Point, about 750 feet from the shore line.
21. Under Project K the partially treated sewage will be discharged into deep water off the outer end of the Key System pier, Oakland.

Construction Cost of Recommended Projects.

22. The estimated total cost of construction of Projects A and K, based upon the general price levels of the year 1940, is \$8,450,000 (see Table No. 88).
23. Based upon the total estimated population of 525,000 tributary in 1945, the computed per capita cost of construction of Projects A and K is \$16.10.
24. Based upon an estimated total assessed valuation of 447.5 millions of dollars in 1944-45, the calculated cost of construction of Projects A and K per \$1000 of assessed valuation is \$18.88.

Annual Costs of Recommended Projects.

25. The estimated total annual costs of Projects A and K are \$719,700 as of 1945 (the assumed date of completion), and \$626,400 as of 1965 (see Table No. 89).
26. The weighted (true) average total annual costs of Projects A and K for the 20-year period, 1945-1965, are estimated to be \$674,200.
27. The estimated per capita total annual costs of Projects A and K for the year 1945 are \$1.37 and those for the year 1965 are \$0.92, based upon population estimates of 525,000 in 1945 and 682,000 in 1965.
28. The estimated total annual costs of Projects A and K per \$1000 of

assessed valuation are \$1.60 for the fiscal year 1944-45 and \$1.31 for the fiscal year 1964-65, based upon estimated total assessed valuations of 447.5 and 476.5 millions of dollars, respectively.

Cost Comparisons Between Recommended Projects and Others.

29. Twenty-four projects serving various sewerage districts or combinations of districts have been laid out, investigated, and subjected to careful estimation of the cost of construction, and of annual costs as of the years 1945 (the assumed year of completion), 1950, 1955, 1960, and 1965.
30. Many combinations of these projects, selected to provide for the entire East Bay area under discussion, are possible and 35 of the more logical of such combinations have been studied and analyzed as to total construction and annual costs (see Tables Nos. 88 and 89).
31. Four of these combinations of projects give a lower estimated total cost of construction than does the combination of Projects A and K.
32. But Projects A and K, taken together and serving the entire East Bay area (excluding San Leandro), give the lowest estimated total annual costs, over the 20-year period 1945-1965, of any of the 35 combinations which have been reviewed.
33. The estimated total construction costs of the 35 combinations of projects studied range from a minimum of \$8,157,000 for Projects A, Q, and R and A, N, and S (both of which exclude San Leandro) to a maximum of \$11,261,000 for Projects C, D, L, V, and X.
34. The weighted average total annual costs for the 20-year period

1945-1965 of the 35 combinations of projects reviewed range from an estimated minimum of \$674,200 for Projects A and K to an estimated maximum of \$959,900 for Projects C, D, L, V, and X (see Table No. 89).

35. In per capita values the computed total annual costs, as of the years 1945 and 1965, range from \$1.37 and \$0.92 for the combination of Projects A and K, to \$1.88 and \$1.26, respectively, for the combination of Projects C, D, L, V, and X; the estimated total populations for Projects A and K being as stated under Item 27; the estimated total populations for Projects C, D, L, V, and X, being as follows: 1945, 543,000; 1965, 707,000 (see Table No. 89).
36. In respect to the calculated total annual costs, as of the fiscal years 1944-45 and 1964-65, per \$1000 of estimated total assessed valuation, the range is respectively from \$1.60 and \$1.31 for Projects A and K, to \$2.25 and \$1.85 for Projects C, D, L, V, and X; the estimated total assessed valuations for Projects A and K being as stated under Item 28; the estimated total assessed valuations for Projects C, D, L, V, and X, being as follows: 1944-45, 453.0 million dollars; 1964-65, 483.0 million dollars (see Table No. 89).

Historical Note Respecting Early Sewerage.

37. The first sewers in the East Bay area apparently were constructed shortly after the year 1869. In 1889 a report by Rudolph Hering on the sewerage of Oakland calls attention to the objectionable results of disposing of sewage along shores and on marshes, intimating that putrefactive odors were becoming aggravated.

Area Served and to be Served.

38. Although not included in the areas of the seven cities cooperating in this Survey, it has not been possible to exclude from consideration the present and future sewerage needs of other areas, including the Stege and San Pablo Sanitary Districts, the lower portions of Wildcat Creek and San Pablo Creek drainage basins, and certain unincorporated territory in Contra Costa County.

Geography of the East Bay Area.

39. Geographically, the East Bay region comprises an area roughly 20 miles in length and about 4.5 miles in average width, lying between the east shore of San Francisco Bay and the crest of the Berkeley-East Oakland hills, and is all a part of the mainland with the exception of Alameda, now an island.
40. The nine incorporated East Bay Cities are contiguous and presently comprise a land area of 55,920 acres, or 87.36 square miles; but annexations to El Cerrito and Richmond may materially increase this area.
41. In the total of 55,920 acres, as stated in Item 40, there are included 15,400 acres, or 24.1 square miles, comprised in parks, heavily industrialized districts, and other areas in which population development of consequence is not anticipated.
42. The inclusion of the Wildcat Creek and San Pablo Creek areas, referred to in Item 38, would add 19,300 acres, or 30.2 square miles, to the total figure named in Item 40.
43. The relatively flat lands, bordering San Francisco Bay, Oakland Inner Harbor, the Tidal Canal, and San Leandro Bay, are open to considerable industrial expansion, especially in Richmond, El

Cerrito, and East Oakland, with a prospect of the more rapid development in the two cities first named.

Topography and Geology of the East Bay Area.

44. The generally pronounced slope of the ground from the eastern hills westerly to the Bay shore furnishes generally satisfactory sewer gradients and correspondingly excellent velocities, with the result that the sewage will arrive at concentration points in a relatively fresh condition and without appreciable odors of putrefaction.
45. A fresh condition of sewage tends to minimize the deterioration of intercepting sewers and of the structures of pumping plants, treatment works and the like, by reducing or preventing the formation of corrosive substances, such as hydrogen sulphide.
46. The formations in which intercepting sewers will be built are geologically stable, but treatment works and outfall sewers, except for Project A, will of necessity require to be located in somewhat unstable materials.
47. Due to the proximity of two active faults in the East Bay area, special precautions with relation to earthquakes must be taken in the design and construction of pumping and treatment plants and of outfall pipe lines located on or in unstable ground.

Climate of the East Bay Area.

48. The climate of the East Bay area is equable, with relatively few days in any year when there is either excessive heat or excessive cold, and neither the normal temperature nor its range between high and low will adversely affect any sewage treatment process.

49. The generally prevailing westerly winds require the removal of floating material of every sort from the sewage as an essential in any form of treatment of sewage which is to be discharged into the Bay waters, in order to insure the future cleanliness of the shores.
50. The fact that the prevailing winds are from a generally westerly direction also makes it obligatory to control effectively odors at sewage pumping and treatment plants, which must of necessity be located along the Bay shore, in order that objectionable odors shall not reach residential areas.
51. The total annual rainfall and the rainfall rates in the East Bay area may be termed moderate, and the precipitation is largely confined to the five months, November to March.
52. As related to sewage treatment, including air drying of sludge, the rainfall regimen is relatively satisfactory and throughout the seven months' period, April to October, it approaches the ideal.

Tides and Currents in San Francisco Bay.

53. Under favorable, controlled conditions the disposal of sewage by dilution represents the most economical and satisfactory method available, but the limiting factors under local conditions compel some degree of treatment, either partial (primary) or complete (final), according to the selected location of the place of out-fall.
54. In 1935 some 3100 places in the United States, with an aggregate population of perhaps 41,000,000, representing 59 per cent of the total population provided with sewerage, were disposing of their sewage by dilution.

55. The controlling factors in the satisfactory disposal of raw sewage or treated effluents by dilution are an adequate volume and depth of diluting water, a sufficient supply of dissolved oxygen, and currents favorable with respect both to direction and velocity.
56. The offshore waters of San Francisco Bay from Point San Pablo to the outer end of the Key System pier and southward generally contain from about 6.5 to 7.4 parts per million of dissolved oxygen, or from about 55 to 63 pounds per million gallons, representing 84 to 94 per cent of saturation, respectively.
57. The general salinity of the waters of San Francisco Bay, offshore from the East Bay area, is closely that of the Pacific Ocean in this region, the respective values observed by the Survey being 17,500 (range 16,200 to 19,700) and 19,000 parts per million.
58. The average tidal range along the East Bay shore is 4.2 feet, from mean low water to mean high water, with a value of about 4.1 feet at Point Richmond, 4.2 feet at the Berkeley pier, and 4.4 feet at the Key System pier.
59. On flood tide Pacific Ocean waters pass inward or eastward through the Golden Gate and divide to fill the tidal prisms in both the north and south portions of the San Francisco Bay system; and, conversely, the ebb tides converge from north and south and pass outward through the Golden Gate.
60. The routes taken by the tidal currents along the East Bay shore are in general the same for both flood and ebb tides, but the velocities at different times during the tidal cycle are markedly different.
61. In general, the currents south of the Berkeley pier are 33 per cent stronger than those north of the pier. The ebb currents in both

places have velocities about 25 per cent higher than the flood currents.

62. On both flood and ebb tides the current velocities obtaining two hours before maximum are several times greater south of Berkeley pier than north; but the reverse is true with respect to velocities two hours after maximum, when those north of the pier are several times as great as those to the south.
63. Tidal currents in San Francisco Bay offshore from the East Bay area are of great importance, because they bring fresh supplies of ocean water to any selected outfall point with whatever weight of dissolved oxygen they may contain as available for the oxidation of organic matter in the sewage or treated effluent discharged at such outfall locations.
64. In terms of actual velocities, the tidal currents along the east shore of San Francisco Bay, from Point San Pablo, Richmond, to the entrance to Oakland Inner Harbor, at all tidal stages (except of course at slack water) are exceedingly favorable, ranging in average values, as follows: north of Berkeley pier, flood tides, 1.5 feet per second; ebb tides, 1.9 feet per second; south of Berkeley pier, flood tides, 2.0 feet per second; ebb tides, 2.7 feet per second.
65. With properly selected offshore outlet locations, tidal current velocities along the east shore of San Francisco Bay, as above indicated, are so large that bottom deposits of sewage sludge could not possibly occur in their vicinity.
66. The Bay waters will always have a temperature lower than that of the sewage, and this condition, coupled with the fact that these

waters will always have a density greatly in excess of that of even the strongest sewage, will cause any stream of sewage introduced at the bottom to rise to the surface, the velocity of such rise being determined by the differential density.

67. In any case, the greater the depth of water at any outlet location the greater will be the length of time required for the stream of sewage to rise from bottom to top, the greater, therefore, will be the lateral displacement or transporting effect of the currents, and the greater will be the degree or extent of diffusion in the mass of diluting water.
68. Where the depth of the diluting body of water is small, multiple outlets for sewage or treated effluents will be of particular value since it will be possible therewith to secure the same degree of dilution and dispersion as with a single outlet in deeper water.
69. Disposal of sewage or treated effluents by dilution must be regarded as a treatment process, subject to definite limitations, just as are the more formal methods of treatment and disposal.
70. Aside from the wind effects referred to in Items 49 and 50, persistent winds actually induce surface currents setting in approximately the same direction, the ratio of induced current velocity to wind velocity ranging from about 1 to 33 for a 10-mile per hour wind to about 1 to 60 for a wind blowing 30 miles per hour.
71. The Survey conducted an elaborate investigation of the velocity and direction of tidal currents at five selected stations, employing 6-foot vane, deep can, and bottle floats in large numbers on various dates and under various conditions of tide and wind, and

found as follows: (1) at Point San Pablo, Richmond, 300 feet and over from the shore, excellent current velocities obtain, and a depth of water not found elsewhere, but the directions are unsatisfactory in that the currents move toward shore lines, and particularly into the shallows north of the Point where yacht harbors have already been developed; (2) in the vicinity of Castro Rocks, about 750 feet from the shore line south of Castro Point, Richmond, the depth is 35 feet at mean lower low water, and both flood and ebb tide velocities and directions are very favorable to the disposal of sewage; rapid diffusion would take place and no sludge deposits could occur; (3) in the vicinity of the outer end of the wharf of the Standard Oil Company, Richmond, about 3,700 feet from the nearest point on shore, the depth is 33 feet, at mean lower low water and both flood and ebb tide velocities and directions are extremely satisfactory from the standpoint of sewage disposal by dilution; (4) in the vicinity of the outer end of the Berkeley pier, Berkeley, about 20,000 feet from the shore line at the foot of University Avenue, the depth is 10 feet at mean lower low water, the currents are most favorable in both direction and velocity and are such that no sludge deposits could possibly occur; (5) in the vicinity of the outer end of the Key System pier, Oakland, about 700 feet west of the end of the pier and 17,600 feet from the general shore line at the mainland end of the mole, the depth is 40 feet at mean lower low water, the currents are extremely favorable in both velocity and direction, showing no tendency to enter Oakland Inner Harbor, and the indicated capacity to receive and innocuously dispose of a properly pretreated (primary) sewage effluent is, practically speaking, almost unlimited.

72. Studies of the probable dispersion areas which might obtain with a succession of tides of various magnitudes, and under six certain tidal conditions as related to slack water, indicate: (1) that these areas are generally of considerable magnitude, ranging from a minimum of 26 acres to a maximum of 685 acres; (2) that the general average area in the vicinity of the outer end of the Berkeley pier is about 133 acres, representing a tidal prism of perhaps 186 million gallons for a single normal tidal cycle; (3) that the general average area in the vicinity of the outer end of the Key System pier is 235 acres, representing a tidal prism of possibly 330 million gallons for a single normal tidal cycle.
73. In connection with the float studies conducted by the Survey, 247 bottle floats, containing return post cards, were allowed to go free in the hope that, if stranded on some shore, they would be found and information of value obtained respecting the dispersion of floating material carried by currents and winds; with the result that 98 bottle floats, or 39.7 per cent of the total number thus released, were found and, through the fine cooperation of many persons, the post cards therein were returned with the desired information concerning the places of recovery.
74. From the experiment described in Item 73 it may perhaps be inferred: (1) that some, if not a majority, of the bottle floats eventually travelled out to sea through the Golden Gate, although this conclusion is uncertain due to the long stretches of almost inaccessible shore line along the East Bay waterfront where the bottle floats would not be found; (2) that wind effects were less pronounced

than might be surmised; (3) that a considerable proportion of sewage solids, if they could maintain their identity, would eventually be stranded on some shore; (4) that the distance of such travel would generally be relatively long; (5) that it will be essential to treat any sewage, discharged at any of the outfall locations studied, to that degree, at least, where virtually all floatable material, including grease, is removed therefrom.

Condition of East Bay Shores and Shore Waters--Further Discussion.

75. Shoaling of the East Bay shores due to silting probably occurred at a relatively rapid rate during and shortly succeeding the period of unrestricted hydraulic mining in California, and this action is still continuing, but at a greatly decreased rate, due to fine material which is being brought down the Sacramento-San Joaquin river system by floods, plus some accretions of coarser materials eroded by the numerous creeks traversing the local area.
76. This shoaling constitutes an argument against any minor extensions of the many existing sewer outfalls on the mud flats.
77. Even a cursory inspection of the Bay shores in the vicinity of any of the existing sewer outfalls clearly reveals the presence of much material obviously of sewage origin, as well as the formation of deposits of putrefying sewage sludge with attendant foul odors and discoloration of shore waters.
78. In confined areas, especially near docks, the waters are particularly obnoxious; gases of decomposition break the surface with continuous bubbling; and gas-lifted sludge masses frequently boil up to the water surface.
79. In the vicinity of certain sewer outlets during the canning season,

solid wastes from the canneries are particularly noticeable and great quantities of floating waste materials may be seen in the Tidal Canal and elsewhere, transported by the currents.

80. In general, the biochemical oxygen demand of the Bay waters is small and of no significance, ranging from an average minimum of about 0.6 to an average maximum of 1.9 parts per million.
81. A detailed study of the condition of the waters of Oakland Inner Harbor, the Tidal Canal, and San Leandro Bay showed that the dissolved oxygen content of these waters was so depleted by sewage pollution that at many points oxygen values below the generally assumed minimum requirements for fish life were found, while at three stations where sampling was conducted in San Leandro Bay the dissolved oxygen was found to be practically exhausted.
82. In nearly the whole length of Oakland Inner Harbor, easterly from Webster Street, the dissolved oxygen depletion is greater than 50 per cent of the oxygen saturation value, the sag being greatest in the vicinity of Government Island.
83. The investigation referred to in Items 81 and 82 clearly demonstrates that the waters of Oakland Inner Harbor, the Tidal Canal, and San Leandro Bay are polluted to an intolerable degree; that they are foul and repulsive; that they are a detriment to industry, commerce and shipping; that they are inimical to fish life; and that they are entirely unsuitable for recreational purposes.
84. Special studies conducted by the Survey have shown that, if the daily increments of sewage solids are removed from the existing sewage sludge deposits on the mud flats and in the bottoms of sloughs and channels, strong, offensive odors will cease to be generated in appreciable amounts after two weeks, and that areas

exposed intermittently to both atmosphere and tidal waters will not produce unsatisfactory conditions in such waters if they contain appreciable amounts of dissolved oxygen.

85. Salt marshes naturally emit comparatively strong, typical odors in the entire absence of sewage pollution in the tidal waters which cover them, in whole or in part; and it cannot be expected that such odors will be eliminated by the treatment or removal of any sewage which may now be present in the tidal waters which ebb and flow over the local salt marsh areas.

Population of East Bay Area--Total and by Sub-divisions.

86. The rates of increase in population in the several parts of the East Bay area are expected to be markedly different.
87. Relatively speaking, the population growth in Richmond and El Cerrito may be expected to be very rapid during the next two decades, at least; that in the west end of Alameda, rapid; and that in the remainder of the area, slow.
88. The population growth of Oakland should be somewhat stimulated during the current decade by the Federal defense program, but thereafter it may be moderate to slow; the growth of Albany, Berkeley and Piedmont will be slow; and the population of Emeryville will actually decrease.
89. The population estimates for the nine incorporated East Bay Cities and for the entire area capable of being served by projects proposed herein, are as follows:

<u>Area</u>	<u>1940</u>	<u>1965</u>	<u>1990</u>
9 Cities	492,000	720,000	779,000
Entire Area	508,000	776,000	944,000

Population Connected and to be Connected with Sewerage Systems.

90. Of the 508,000 persons living in the East Bay area in 1940, all but 8,000, exclusive of the population resident in and about Orinda, are connected with the existing sewerage systems.
91. About 60 per cent of the unconnected population of the area live in the sparsely settled hill districts of Oakland and the remainder in the drainage areas of Wildcat and San Pablo Creeks, naturally tributary to the San Pablo Sanitary District.
92. The unconnected population in Oakland has been substantially reduced during the past 10 years and at the present rate of decrease most of the remainder will have been provided with sewerage facilities during the next five years.
93. Proceedings for annexation to the San Pablo Sanitary District have been initiated to provide sewerage for a large portion of the populated areas in the lower parts of the Wildcat Creek and San Pablo Creek watersheds.

Water Supply of the East Bay Area.

94. The water supply of the East Bay area, as furnished by the East Bay Municipal Utility District, is comparatively soft and low in sulphates, both of which factors are favorable in relation to the maintenance and operation of intercepting and other sewers, to pumping plants, to sewage treatment plants, and to outfalls.
95. The public water supply is completely metered with the result that the volume of sewage per capita is relatively low as related thereto, but there is apparently a definite trend toward an increasing per capita use of water, which is expected to be reflected in moderate increases in the contribution to sewers.

96. The estimated average total and per capita water consumption, as supplied and predicted to be supplied by the East Bay Municipal Utility District in certain stated fiscal years, is as follows:

<u>Date</u>	<u>Estimated Population</u>	<u>Consumption - Gallons per Day</u>	
		<u>Total</u>	<u>Per Capita</u>
1939-40	519,000	39,800,000	76.7
1944-45	650,000	51,400,000	79.1
1949-50	754,000	63,100,000	83.7
1954-55	868,000	76,000,000	87.6
1959-60	999,000	90,800,000	90.9
1964-65	1,124,000	105,300,000	93.7

97. In the aggregate, a considerable amount of water for manufacturing purposes is obtained by some of the local industrial establishments from the ground or from other sources additional to the supply furnished by the East Bay Municipal Utility District, and must be considered in estimating sewage flows because it helps to swell the total contributions thereto in industrialized areas.
98. In order to determine the possible effect upon sewage flow of the private water supplies referred to in Item 97, an estimate of the amount of water so used in 1940 and predicted to be used in the future, has been made for each of the 36 sewerage districts in the East Bay area; and these figures have been combined with segregated estimates of consumption for domestic and for industrial purposes, as obtained from the East Bay Municipal Utility District, with results as follows:

<u>Water Consumption - Millions of Gallons per 24 Hours</u>					
<u>Date</u>	<u>Total</u>	<u>Domestic</u>	<u>Industrial</u>	<u>From</u>	
				<u>E.B.M.U.D.</u>	<u>Private Sources</u>
1940	43.4	30.5	12.9	37.3	6.1
1965	79.1	59.5	19.6	72.1	7.0
1990	99.9	77.6	22.3	92.6	7.3

Existing Sewerage Systems in the East Bay Area.

99. All of the East Bay area considered in this Report is or can be served by the existing sewerage systems with the possible exception of the lower Wildcat and San Pablo Creeks watersheds, as indicated in Items 90 and 91; most of the necessary trunk lines are now, by reason of original competent design or by later construction, of adequate capacity, except possibly in newly developed regions, particularly in Richmond.
100. The various sewerage systems of the East Bay area, probably beginning in Oakland, have been constructed over a period of 70 years, and always, unfortunately, without the benefit or guidance of a comprehensive plan.
101. Many of the oldest sewers constructed of various materials, particularly in Oakland and Alameda, have served their useful life and either have or will soon be replaced with more durable materials.
102. Many of the trunk sewers of the area have been constructed across the lower flat lands to reach and serve the upper hill areas, for which provision had not been made in the original design, with the result that duplication of lines and extra maintenance costs have been involved.
103. Excessive infiltration due to poor construction occurs in numerous lateral sewers installed by real estate development companies probably without sufficient inspection.
104. The surreptitious connection of roof leaders and yard drains to house sewers has created untenable conditions in many sections of the several cities.
105. The connections, referred to in Item 104, are generally prohibited by city ordinances, which unfortunately have not been adequately enforced.

Sewage Quantities--Total and by Sub-divisions.

106. There are four principal classes of contributions to sewers, namely: (1) domestic, or so-called sanitary sewage, from residences and from commercial and industrial establishments; (2) process or trade wastes from industrial establishments; (3) storm waters from street and other surfaces (in combined sewers and storm drains); (4) sub-surface water infiltration into all types of sewers.
107. No storm waters, from roofs or streets, should be allowed to enter any separate sanitary sewer, but unfortunately that is not the case locally and many such sewers do receive large quantities of storm water.
108. An adequate knowledge of the quantities of sewage to be handled is fundamental to the planning and design of almost every feature of sewerage works, including the sewers themselves, the pumping plants, the treatment works, and the outfalls.
109. Very little competent information relative to sewage quantities in the East Bay Cities was available from the previous records for the use of the Survey.
110. It is extremely unfortunate that combined sewers have been constructed in the East Bay area, in view of the fact that practically all of the dry weather flow of sewage and the contribution of industrial wastes must eventually be treated to a definitely certain extent before being discharged into the waters of San Francisco Bay or its annexa, such as smaller bays, harbors, sloughs, etc., if these last were to be so utilized.
111. An elaborate series of gagings of sewage flow was conducted by the Survey at eleven carefully selected stations well distributed

throughout the East Bay area and representing, because of the limitations imposed by local conditions, typical sewerage districts of a predominantly domestic character. For the most part the measurements were carried through an entire week representing dry weather conditions; and the following general data were obtained:

(1) the average daily per capita sewage flow, as between the different stations, ranged from a minimum of 37 to a maximum of 91 gallons, and averaged, for all stations, 58 gallons; (2) the average daily per capita water consumption in the districts tributary to the eleven sewage gaging stations in question, ranged from a minimum of 35 to a maximum of 96 gallons and averaged for all areas 72 gallons; (3) the ratios of average maximum to average daily rates of sewage flow ranged from a minimum of 1.64 to a maximum of 2.14 and averaged 1.88; (4) the minimum average rates of flow at the several stations ranged from a minimum of 24 to a maximum of 46 per cent of the average daily rates, the general average percentage being 32; (5) the ratios of average daily water consumption for the year 1939-40 to the average daily sewage flow, as measured in 1940 at the several stations, ranged from a minimum of 0.98 to a maximum of 1.75 and averaged 1.23.

112. Where industrial developments are large, as they are in many areas in the East Bay Cities, the contributions of trade wastes may be very heavy in terms both of volume of flow and of strength.
113. In order to make proper allowances for the bulk and character of industrial wastes in the various existing sewerage districts and proposed projects (since the flow measurements and sewage sampling at the several gaging stations referred to in Item 111 represent

predominantly domestic sewage) it was necessary to make a canvass of the industrial establishments in the entire East Bay area and to determine, by inquiry and measurement and by sampling and laboratory analysis, the nature and amount of liquid wastes contributed to the sewers. This canvass revealed the existence of 411 industrial establishments in the area; 135 of these were visited and the necessary information obtained; and the flows of 27 were determined by gagings.

114. The older sewers throughout the district (and altogether too many of those more recently constructed as well) have been poorly built, with the result that great quantities of ground water enter them not only after storms, but generally whenever and wherever the ground water table remains permanently above the level of the sewers or rises temporarily to elevations above their levels.
115. Careful measurements of infiltration rates were made at several of the sewage gaging stations referred to in Item 111, with results as follows: (1) in terms of gallons per acre per day, the flows of the first day following storms varied from perhaps 800 to 2700, and averaged about 2000; (2) in the same terms for the second day the figures ranged from somewhat above 600 to 2300, and averaged about 1600; (3) from 2 to 20 days were required for flows following storms to recede to the equivalent of 1000 gallons per acre per day, the average period, with certain limitations stated in the Report, being slightly more than 7 days; (4) the provision of 1000 gallons of infiltration water per acre per day appears to represent a rational allowance for treatment plant design, any excess above that quantity to be taken care of according to the conditions of each particular case.

116. As indicated in Items 107 and 110, many of the sewers in the East Bay Cities are combined sewers, that is, they carry both sanitary sewage, so-called, and storm drainage; and in many other cases the sewers which are termed sanitary sewers are such only in name in that they receive large quantities of roof water and street drainage, contrary to their avowed purpose or design.
117. It is obvious that sewage treatment plants cannot be designed either rationally or economically to receive such excessive flows of storm water and that such flows, in excess of the design capacity of these works, must be by-passed, generally through existing outfalls.
118. The existing local conditions, and those which will obtain under the projects proposed herein, are such that no significant impairment of the fundamental objective of these projects will result from this by-passing of excessive flows.
119. All pumping plants must necessarily be designed to handle all of the flow which is permitted to reach them, and in some instances it will be required that certain pumps will deliver to the treatment works and others to specially provided by-passes.

Character and Composition of the Sewage of the East Bay Cities.

120. In the layout and design of sewage treatment and disposal works competent information concerning the character and composition of the sewage is quite as indispensable as that concerning its volume; but this vital matter is all too frequently neglected or overlooked with the result that sewage treatment plants are too often inadequate and inefficient.
121. Until the Survey began its work no definite, dependable information

was available concerning the character and composition of the sewage and industrial wastes of the East Bay area.

122. It was therefore necessary to establish a well equipped laboratory with trained personnel, since no other laboratory, already equipped to handle the great volume of the contemplated work, or work of its highly specialized nature, was available.
123. Sewage varies enormously in composition as between the different hours of the day and the several days of the week, and sampling was conducted at the gaging stations referred to in Item 111 to show these variations and to determine the general average character and composition of the dry weather flow, or undiluted sewage.
124. The laboratory analyses revealed the great variation which must be anticipated with respect to sewage strength during different hours of the day; that the strongest sewage obtains when the rates of flow are high or highest, and that the weakest sewage obtains during the early morning hours when the rates of flow are uniformly relatively very low and are comprised mainly of ground water.
125. The most significant characteristics of sewage, as related to treatment and to the disposal by dilution of a partially treated (primary) effluent, are suspended solids, biochemical oxygen demand, and grease.
126. Sewage treatment plant loadings, in terms of the constituents named in Item 125 and of certain other composition factors, and because of the variations stated in Item 124, may be expected to vary enormously, with weight ratios in terms of total pounds per day of typical domestic sewages averaging somewhat as follows:

<u>Constituent</u>	<u>Ratios</u>		
	<u>Max. to Min.</u>	<u>Max. to Aver.</u>	<u>Aver. to Min.</u>
Suspended Solids	580	4.1	126
Biochemical Oxygen Demand	142	2.2	62

127. However, since the sampling conducted at the several stations referred to in Item 111 gave data for predominantly domestic sewage only, true plant loadings for the various treatment works planned for the projects proposed herein must be determined by computing the load contributed by domestic sewage and adding thereto the determined contributions of the principal industries.
128. The domestic sewage of the East Bay Cities may be classed as moderately strong with a composition as shown by the following figures:

<u>Constituent</u>	<u>Parts per Million</u>		
	<u>Average</u>	<u>Observed Maximum</u>	<u>Observed Minimum</u>
Suspended Solids	293	900	4
Biochemical Oxygen Demand	284	700	7
Grease	52	154	5

129. The East Bay Cities may well boast of a large and diversified industrial development which is of immense concern in matters of sewer and sewage treatment plant design because industrial wastes are commonly of great volume and strength.
130. It is not unusual for a few industrial establishments to contribute a greater load of suspended solids and biochemical oxygen demand, particularly the latter, than the entire population tributary to the sewerage system of a community. In view of this fact the Survey collected and analyzed a large number of different kinds of industrial wastes and supplemented these comprehensive data with

valuable information gathered from other sources, all of which have been tabulated in great detail and presented in the Report in such terms that they can be applied to similar procedures in this area or elsewhere if the weight of the raw product processed is known. Furthermore, they have been utilized in computing the probable composition of present and future contributions of domestic sewage plus industrial wastes to the treatment plants proposed herein.

Special Laboratory Investigations Conducted by the Survey.

131. In sewage treatment plant layout and design it is essential that the behavior of the sewage undergoing certain phases of treatment shall be predictable and, while this behavior can be predicted with considerable confidence for certain final treatment processes from the character and composition values, it cannot be predicted so assuredly from the purely analytical data as related to clarification by settling, to the removal of grease, and to disinfection by chlorine.
132. Comprehensive investigations conducted in the Survey's laboratory on the behavior of the local sewages and industrial wastes with mechanical (without chemicals) and with chemical coagulation demonstrated: (1) under laboratory conditions, 15 minutes of plain stirring (mechanical flocculation) followed by 20 minutes of quiescent settling, will give about the same removals of suspended solids and biochemical oxygen demand as plain sedimentation over an indefinite period of time; (2) of three coagulants tested, alum, ferric chloride, and a bentonite clay, alum only gave satisfactory coagulation results with all of the sewage samples employed in the

investigation, and with alum very high removals of suspended solids could be obtained by an appropriate, but always heavy and costly dosage.

133. By special laboratory tests directed at the elucidation of this matter, it was demonstrated that the routine laboratory determinations of 5-day biochemical oxygen demand, $20^{\circ}\text{C}.$, performed according to "Standard Methods" with the use of sodium bicarbonate water, are reliable criteria for estimating oxygen consumption in salt as well as in fresh water sewage disposal practice.

Sewage Treatment Plant Loadings.

134. The total weight of any sewage constituent for any given period of time may be computed from its determined value in parts per million and the average rate of sewage flow during that same time period, the resulting value denoting the "plant loading" for that constituent for the time interval in question.
135. The influence of loading upon plant design and operation is somewhat dependent upon the extent or degree of treatment; with primary or partial treatment its influence being less than with complete or final treatments, i.e., those producing stable effluents.
136. While it is true, for a given quality of effluent with respect either to suspended solids or biochemical oxygen demand, that the displacement period in plain sedimentation basins is less with weak than with strong sewages, the practical effect upon design, as commonly practised, is small.
137. If, however, the sewage is to undergo complete treatment--under local conditions, trickling filtration or the activated sludge process--the processes which follow primary treatment are greatly

- affected by the characteristics of the sewage; that is, by the plant loadings as defined in Item 134.
138. Processes yielding a stable effluent can be substituted for disposal of partially treated effluents where treatment plant locations are such that dilution waters in adequate volume cannot economically be reached.
139. The effect of the sewage composition, as such, will be negligible upon the design of settling tanks, pumps and piping, including outfall lines, but marked with respect to the size of sludge digestion tanks, the kind and capacity of sludge drying equipment and, in a measure, to the location and design of the submerged outlet structures at the discharge ends of outfall lines.
140. In a region where seasonal crops are processed, as in the East Bay area, the amount and character of the solids contained in the wastes from canneries and other processing plants become important factors in the design of sludge digestion tanks and require that the capacity of these must recognize this circumstance, and be correspondingly increased over that ordinarily provided for sewage which does not contain significant amounts of such wastes.

Selected Points of Disposal of Treated Sewage in San Francisco Bay Waters.

141. The objectives which must be attained locally in the selection of points of disposal of a partially treated sewage effluent by dilution are: (1) the volumetric ratio of diluting water to sewage or treated effluent must be ample at all times and, for a primary or partially treated effluent discharged into otherwise clean water of normal dissolved oxygen content, satisfactory conditions will

obtain if this ratio is 225 to 1; (2) the settled effluent must be widely dispersed into and intimately mixed with the diluting water. In the disposal of sewage or a treated effluent by dilution, time, sunlight and the action of minute marine organisms all act as purifying agents in addition to the oxidizing action of the oxygen dissolved in the receiving water.

142. The phenomena attending the dilution of a sewage or sewage effluent when discharged at an appreciable depth in salt water are: (1) the sewage rises to the surface because it is appreciably lighter than the salt water by reason of a higher temperature and a lower density; (2) the shape of the rising column of sewage approximates that of an inverted cone with a widely flaring lip at the water surface; (3) the rising stream of sewage, according to its quantity and the depth of the body of water into which it is discharged, is diluted with a varying, but always considerable, amount of the receiving water; (4) at the point where the cone of mixed sewage and salt water breaks the surface, its diameter is roughly one-third of the length of path travelled from the point of discharge; (5) the mixed liquids then form, in the absence of currents, a roughly circular surface layer approximating in thickness one-twelfth the length of path so travelled; (6) this layer then spreads laterally until sufficient dilution has been acquired to destroy the identity of the sewage or sewage effluent; (7) if an appreciable current obtains, the form of the surface layer of diluted sewage or sewage effluent will be modified and will assume a roughly triangular shape drifting with the current until its identity is lost.
143. The studies made by the Survey with 6-foot vane floats are of particular value in determining the influence of Bay currents

upon sewage fields and, in general, upon the dilution of sewage or sewage effluents.

144. The selected point of disposal, under Project A, of a partially treated (primary) sewage effluent near Castro Rocks, 750 feet offshore from the vicinity of Castro Point, is ideal because strong currents, parallel to the general shore line, prevail here and the depth of water over outlet of 35 feet at mean lower low water has been maintained since the early soundings in San Francisco Bay were made in 1855.
145. The conditions at the selected point of disposal under Project B, a short distance offshore westerly from Point Richmond (Ferry Point), where the depth is about 20 feet at mean lower low water, require that a higher degree of treatment be given to the sewage than that afforded by plain sedimentation, because the currents here enter Richmond Inner Harbor.
146. Sewage discharged in accordance with Project C, either at the end of the training wall of Richmond Inner Harbor or at the west shore line of Brooks Island, will require a high grade oxidizing treatment, as by the activated sludge process, to insure continually satisfactory conditions.
147. Under Projects D, E, F, and G, with disposal of a partially treated (primary) sewage effluent near the outer end of the Berkeley pier where the depth of water over outlet is about 10 feet at mean lower low water, the conditions are such that, by the use of multiple outlets, disposal may be effected with entirely satisfactory results.
148. Under Projects H to Q, with disposal of a partially treated

sewage effluent near the outer end of the Key System pier where the depth of water over outlet is 40 feet at mean lower low water and strong currents prevail, the conditions are highly favorable to the satisfactory disposal of practically unlimited quantities of such treated effluent.

149. For Projects R, S, and T, disposal of sewage effluents into the northeasterly area of San Leandro Bay will require that the effluent be highly oxidized, since the conditions for satisfactory dilution and dispersion are not to be found in this location.
150. For Projects U and V, and also for Project W, the conditions in San Francisco Bay offshore from the general region of the Oakland Municipal Airport are such that disposal of a partially treated (primary) effluent cannot be satisfactorily effected with an outfall of any reasonable length, and therefore some more effective form of sewage treatment is indicated on economic, hygienic and aesthetic grounds.
151. For Project X (Alameda alone) discharge of a relatively well oxidized effluent, such as one produced by the activated sludge process, through an outfall extending a short distance from shore along the south bank of Oakland Inner Harbor, should be continually satisfactory.

Partial versus Complete Sewage Treatment for Local Conditions.

152. Two general possibilities are open to the East Bay Cities for treatment and disposal of sewage with the achievement of identical objectives, namely: (1) partial treatment to remove the larger suspended particles and the floating material, including grease, with ultimate disposal of the effluent in deep water

where strong currents will insure adequate dispersion and the available oxygen will oxidize the unstable organic matter to stable compounds; (2) relatively complete treatment which will yield a highly clarified effluent low in oxygen demand suitable to be discharged at a shore line where the available volume of diluting water is comparatively small.

153. For various reasons already indicated, it is not proper, under local conditions, to discharge partially treated (primary) sewage at a shore line because the ensuing bacterial contamination of the shore and shore waters would be massive and conditions obnoxious to sight and smell would almost surely prevail.
154. Partial treatment of sewage with the disposal of the resulting effluent in deep water, well offshore where satisfactory tidal currents prevail, compared on bases of construction and total annual costs with complete treatment by the activated sludge process, with disposal of the resulting effluent at the shore line, is demonstrated to be far less costly, under local conditions. This conclusion is valid not only as of the present but also of the reasonably distance future.

Discussion of Possible Projects.

155. The criteria which determined the selection of each of the 24 projects outlined, discussed and subjected to rigorous analysis with respect both to construction and total annual costs in this Report are primarily these: (1) lands suitable in area, location and other features for pumping plants and treatment works easily reached by the shortest possible lengths of interceptors; (2) service to the maximum acreage of low land without

unnecessary and irrational supplementary pumping; (3) maximum utilization of the existing facilities, such as the Berkeley and Key System piers, thereby contributing to an economic solution of the problem; (4) accessibility of a suitable location for the ultimate disposal by dilution of the treated sewage effluent; (5) favorable topography; (6) favorable formations as related to excavation, foundations, etc.; (7) engineering judgment with relation to all of the above factors and such others as might be of controlling influence in specific cases.

156. The 24 projects in question naturally arrange themselves into four groupings according to the principal city served, as follows: (1) A, B, and C, serving Richmond; (2) D, E, F, and G, serving Berkeley; (3) H to W, inclusive, serving Oakland; (4) X, serving Alameda.
157. All projects involving the collection and disposal of the sewage of central Oakland (Sewerage District No. 15) are complicated by the great volume of storm water carried in the combined sewers, and by the fact that insufficient grades are available to discharge these storm waters by gravity across the filled lands to the Bay shore.
158. The provision of a storm water pumping plant, located in or adjacent to the main sewage pumping station proposed under Project K in the vicinity of the foot of Twenty-second Street, with discharge through a pressure outfall to Oakland Outer Harbor, may prove to be the economical solution of the problem of affording effective relief for part of those west Oakland areas which are flooded by every storm of more than moderate intensity.

159. The problem stated in Item 158 concerns the City of Oakland solely, and since it relates only indirectly to the matter of sewage disposal it has not been considered in detail by the Survey.
160. Sound municipal financing and good public policy are represented in the provision, at the present time, of adequate sewerage and sewage disposal facilities for areas which may be annexed in the future to existing incorporated communities, as has been proven by many similar experiences in California, and this policy has been adopted by the Survey in the planning of all projects proposed herein.

Types of Construction of Sewers and Treatment Works.

161. For intercepting sewers, vitrified clay pipe is generally the best of all available materials up to the maximum sizes in which it is commercially manufactured, but its strength limitations must be recognized.
162. Above about 30 inches in diameter, at the present time, modern concrete pipe, reinforced and manufactured by processes which insure maximum density, is acceptable for intercepting sewers under controlled conditions.
163. Precast concrete pipe, of the sort referred to in Item 162, is manufactured by the centrifugal process up to a diameter of about 75 inches and above that to a diameter of 12 feet or more by vertical casting with vibratory consolidation.
164. Monolithic concrete sewers, cast in place, are also acceptable for the conveyance of sewage under controlled conditions.
165. Concrete sewers subject to the heavy attack of hydrogen sulphide should be provided with vitrified clay liners jointed with a

- suitable sulphur-silica compound to prevent destruction by acid disintegration, or else possibly protected from corrosion by forced ventilation, or by the application to the sewage of appropriate chemicals.
166. Acids from certain industries will attack and destroy concrete pipe and must therefore be excluded from sewerage systems containing such pipe in the vicinity of such discharges.
 167. Experience indicates that if the transit in sewers occupies more than about 4 hours the sewage may become septic, with the consequent formation of hydrogen sulphide gas. This gas, in the presence of moisture condensed on the walls of the sewer above the line of flowing sewage, will form a weak acid which will attack and disintegrate concrete.
 168. Where concrete sewers are installed, special procedures to prevent the formation of hydrogen sulphide gas, such as the application to the sewage of liquid chlorine, ferrous salts, or zinc salts, may be invoked.
 169. Under the conditions which will probably obtain in the intercepting sewers planned in connection with the projects proposed herein, it is anticipated that the extent of the formation of hydrogen sulphide gas will be so slight that it will constitute no serious problem.
 170. Cast-iron pipe is generally the most suitable sort for the conveyance of sewage in pumping and treatment plants, and is an excellent type where salt water corrosion otherwise may be significant.
 171. Steel pipe is commonly attacked rapidly by both sewage and sea

water and may also be destroyed by electrolysis.

172. In the past sewer pipe joints have represented one of the weakest features of construction and commonly have been of porous or leaky character, but modern materials and methods may now permit of uniformly satisfactory results if due care is exercised.
173. Sewers constructed of brick or tile are not to be recommended in areas subject to seismic disturbances.
174. Concrete, plain and reinforced, is a satisfactory as well as the most available and rational material for the structures of pumping plants and treatment works.
175. Foundations for pumping stations, treatment plants and large conduits constructed on mud flats, filled ground or other unstable materials must either be consolidated with piling or provided with suitable supporting piles.
176. In laying submarine outfalls the Bay floor should not be excavated but should be left undisturbed, and such lines should preferably be supported on capped pile bents.
177. Inverted siphons, so-called, or U-shaped pipe lines, as well as long force mains, should be avoided wherever possible, but multiple-barrelled U-shaped pipe lines can be operated without serious difficulty.
178. By-pass structures, to spill excess flows during storm periods directly to the Bay, should be as simple as possible, very rugged, and carefully designed and constructed to accomplish unfailingly their purpose.
179. No conditions will be encountered in the execution of the works proposed for construction under the projects recommended herein which cannot readily and effectively be met through good design,

good construction, and the utilization of sound materials.

Unit Costs.

180. The estimation of construction cost is commonly accomplished by determining the numbers of units in the different features of elements of a plant or project and applying unit costs thereto, adding suitable percentages to cover contractor's profit and an allowance for engineering and contingencies. This procedure was followed whenever possible in developing the construction cost estimates for the 24 projects proposed herein.
181. Similarly, the estimation of certain features of annual costs can be so accomplished and these devices, together with many others, were employed in calculating the various items which go to make up annual costs.
182. The methods of cost estimation employed for the projects proposed herein were such that all projects are comparable among themselves, and their relative economic advantages and standing will not be affected materially by changes in price levels and wage scales.

Recommended Projects--Further Discussion.

183. All combinations of projects studied in connection with this Report are presumed to solve the sewerage and sewage disposal problems of the East Bay area with equal effectiveness judged from a physical standpoint, but this is not entirely the case inasmuch as combinations of projects in which Projects U, V and W appear cannot be considered as equally effective or desirable in a physical sense as compared with groups in which these projects are absent.

184. The ultimate criterion of selection of any project or combination of projects must rest in the total annual costs over a reasonably prolonged period, preferably the effective life of the entire project or projects or, in any event, that of certain principal elements.
185. In the present case the general capacity-life of sewage pumping and treatment works under all projects, as related to equipment but not to structures, has been planned for 20 years, and this provision applies generally to outfall pipe lines also.
186. For the fundamental reason stated in Item 185, all annual costs have been computed for a 20-year period beginning in 1945, the assumed date of completion and start of operation, and the costs have been calculated in detail as of the years 1945, 1950, 1955, 1960, and 1965, with all average costs for the period determined as weighted values.
187. The only exception which might be taken to the selection of a project or projects on the basis of the involved annual costs would be represented by the condition that the construction cost is too great to be assumed by the community because of debt limitations; but this situation would not exist with respect to Projects A and K because, for one reason, they will presumably be constructed as a general enterprise undertaken by the entire group of cities, sanitary districts and other tracts comprising the East Bay area, so that any discussion of excessive or extravagant construction costs is of academic interest only.

Economy of Projects A and K Relative to the Several Cooperating Cities Individually.

188. A critical analysis of the relative economy of the combination of

Projects A and K to the individual cooperating cities definitely shows the marked advantage of the joint solution for the cities of Berkeley and Alameda, and inferentially for Albany.

189. For Berkeley the figures of average annual costs for the 20-year period, 1945-1965, indicate an average annual saving of 41 cents per capita and 64 cents per \$1000 of assessed valuation, the respective percentages being 27 and 34.
190. For Alameda the indicated average annual savings are 84 cents per capita and \$1.56 per \$1000 of assessed valuation, representing respectively 45 and 55 per cent.
191. For Oakland, Emeryville, and Piedmont, taken together, there is a slight but definite economic advantage in the joint Project K over an independent project such as Project H, the indicated average annual savings being 8 cents per capita and 4 cents per \$1000 of assessed valuation; the advantage in terms of per capita construction cost is estimated to be 58 cents; but there is an estimated disadvantage of 4 cents per \$1000 of assessed valuation in construction cost.
192. Reasons other than relative economy, however, may be decisive for Oakland, Emeryville, and Piedmont as related to a joint undertaking with the other cooperating cities, even if such joint undertaking were only of equivalent economy as compared with some independent project.
193. It may therefore be concluded that it is definitely not in the interest of Alameda, Albany, Berkeley, El Cerrito, Emeryville, Oakland, and Piedmont to attempt individual solutions of their sewage disposal problems, but that, instead, cooperative action

under joint Project K is advisable, economic, and advantageous to all.

194. For Richmond the best solution of the problem of sewage disposal will be found under Project A.

Constructing Agencies for Recommended Projects.

195. The East Bay Municipal Utility District, a "going concern", is the logical agency to conduct the financing, planning, designing, constructing, and operating of the comprehensive sewerage, sewage treatment and disposal works needed for the East Bay Cities provided some additions are made to its clerical and technical staffs.
196. The development and distribution of a public water supply and the construction and operation of sewage disposal facilities have many functions in common and draw upon the same general fields of technical knowledge.
197. If for any reason the citizens of the East Bay area decide that it is not expedient to consign the construction and operation of sewerage and sewage treatment and disposal works to the East Bay Municipal Utility District, it will be legally possible to accomplish the desired objective under the provisions of the Joint Municipal Sewage Disposal District Act of 1941, or under "An Act Relating to the Joint Exercise of Powers by Cities or Counties", Statutes of 1921, page 542, as amended in 1941.

Sequence of Construction of Units of Recommended Projects.

198. The problems of sewage disposal are less acute in the Richmond area than elsewhere in the East Bay Cities, and for that reason

the construction of Project A is not immediately required and may properly be deferred for possibly several years.

199. The sewage disposal problem of the remainder of the East Bay area is definitely acute so that the construction of Project K should be begun at an early date and vigorously prosecuted to completion.
200. In constructing Project K the sequence of construction and the number of contract units should be properly determined and scheduled to the end that all units shall be available for use when completed, thus minimizing the cost of interest prior to full utilization of the works.

Possible Credits from Utilization of By-Products of Sewage Treatment.

201. For treatment plants of the type proposed under the recommended projects A and K, it is possible that a slight net reduction of annual costs may be obtained through the utilization of combustible gases resulting from the digestion of sewage sludge to produce electric power and heat at the treatment plants, and this matter should receive careful study when the final designs are prepared.
202. Either the air-dried digested sludge produced under Project A, or the 70 per cent moisture filter cake produced under Project K, have substantial fertilizer values of the order of \$10 per dry ton, and there is an available local market therefor represented by regional and municipal parks.
203. The sale of this sludge to park authorities at agreed reasonable prices would be mutually advantageous and would produce a revenue which might offset possibly 7 per cent of the total annual cost of Projects A and K.
204. The added costs of equipment and operations and the uncertainties

involved in the general marketing of sewage sludge fertilizer make it inadvisable to engage in the business of producing, packaging and selling kiln-dried sludge for fertilizer under local conditions.

205. The experience at Milwaukee and Pasadena in producing and marketing a fertilizer from activated sludge containing about 4 per cent of nitrogen is not applicable to fertilizer produced from digested sludge containing barely 2 per cent of nitrogen.
206. No definite, firm market for a highly clarified and stable sewage effluent appears locally probable at the present time, and the reclamation of such an effluent for industrial or other uses will be costly to the extent that it would offer little or no price advantage as compared with the publicly owned water supply in large quantity rates.

Methods of Financing Projects.

207. The estimated annual costs of the projects proposed herein have recognized the issuance of 40-year serial bonds, bearing an interest rate of 3 per cent, with retirement beginning as of the year 1945.
208. The bond period of 40 years approximates the weighted effective useful life of the aggregate of the units of all sorts comprehended by the projects.
209. General obligation bonds are to be preferred to revenue bonds.
210. If, as recommended, the projects are constructed and operated by the East Bay Municipal Utility District, it will be possible to defray the cost of construction and operation of the projects:
(1) by taxation only; (2) by charges upon water service only; (3) by both taxes and charges.
211. The ultimate decision in the matter referred to under Item 210 must

rest upon the determination of that procedure which will represent the best public policy.

Temporary Relief.

212. Numbers of proposals have been made for temporary relief from the existing objectionable conditions of the shores and shore waters of the East Bay area pending the construction and operation of permanent works for adequate and decent disposal of the sewage of the region.
213. The proposals in question, however, have been concerned almost solely with the western waterfront situation and have practically ignored the equally foul conditions in Oakland Inner Harbor, the Tidal Canal, and San Leandro Bay.
214. All of the proposed measures for temporary relief involve: (1) excessive costs, as with fills; (2) uncertainties as to both cost and results, as with chemical treatment; (3) complications as to public policy in relation to the improvement of privately owned lands at public expense.
215. The cost of all suggested temporary relief measures are beyond the current or annual financial resources of the East Bay Cities involved.
216. No feasible project for temporary relief has been disclosed which can be effected at reasonable cost and without an unwarranted waste of public funds.

Local Ordinances and Practice Relative to House Sewers.

217. The ordinances of the several East Bay Cities vary appreciably in their requirements concerning the installation of house sewers:

in Albany, Oakland, Piedmont and Richmond the complete house sewer from street sewer to building is constructed by private contract under inspection by the plumbing inspector; in Alameda, Berkeley, Emeryville and El Cerrito the city constructs and maintains that portion of the house sewer which is within the city street; the latter procedure being preferable.

218. Past practice in house sewer installation gives evidence of careless workmanship, poor inspection, and damage to street sewers, all of which have resulted in gross and unnecessary infiltration of ground water.
219. Definite, modern and precise regulations governing the discharge of acid wastes and other detrimental liquids or solids into sewers do not exist in the present ordinances; adequate, uniform regulations controlling these matters should be enacted and incorporated in the several municipal plumbing codes.
220. The City of Oakland and perhaps other cities permit sub-surface drainage systems to be connected to sanitary sewers, a practice which should be prohibited and the existing installations removed from the sanitary sewers.
221. Regulations of the several cities governing the installation of roof leaders are frequently inconsistent within themselves, apparently prohibiting the discharge of roof water into sewers in one section of an ordinance or code, and in other part of such code, or in another ordinance, permitting the practice under some inconsistent exception or under some form of administrative discretion; all codes should definitely and uniformly prohibit the discharge of rain water, from whatever source or by whatever means, into the sanitary sewers.

222. The past and present deficiencies in regulations and practices of the East Bay Cities in respect to house sewers and rain water drains will result in an unnecessary extra cost of intercepting sewers, pumping stations, treatment works and outfall sewers required for the adequate and proper disposal of sewage from this area.
223. The defects referred to in Items 218, 220 and 221 are also responsible in part for the spouting of sewer manholes during and after rain storms, with resulting nuisances of particularly vile types at many points.
224. Ventilating manhole and lamphole covers are not required or desirable and such covers should no longer be used.

Table No. 40

East Bay Cities Sewage Disposal Survey - 1941 Report

ESTIMATED COST OF CONSTRUCTION OF PROJECT A

RICHMOND: CASTRO POINT

To Serve Sewerage Districts Nos. X, Y, 1-5, Inclusive, and 25 Per Cent of 6

See Table No. 31 and Plates 89, 90, and 92

Item	Estimated Cost
Intercepting Sewers, Tunnel* and Force Mains	\$ 778,000
Diversion Structures	3,000
3 Pumping Plants - Structures	60,000
3 " " - Equipment	40,000
Treatment Works - Structures	192,000
" " - Equipment	115,000
Outfall Pipe and Outlets	85,000
Land, Rights of Way, Miscellaneous Structures	30,000
TOTAL	\$ 1,303,000
Engineering and Contingencies - Add 20 per cent	261,000
TOTAL	\$ 1,564,000

NOTES: Population: 1940, 39,640; 1965, 132,600; 1990, 239,300

Estimated Dry Weather Sewage Flow, Millions of Gallons per 24 Hours:

1940, 1.86; 1965, 8.12; 1990, 15.7

Sizes and Lengths of:

Interceptors:	57,400 feet - 10" to 72"
Force Mains:	2,500 feet - 12" to 24"
Outfall:	1,000 feet - 42"

Type of Treatment: Settling, Grease Removal, Sludge Digestion, and Sludge Drying Beds.

* Tunnel 1700 feet in length with 66 inch pipe laid through.

Table No. 50

East Bay Cities Sewage Disposal Survey - 1941 Report

ESTIMATED COST OF CONSTRUCTION OF PROJECT K

OAKLAND: KEY SYSTEM PIER

To Serve Sewerage Districts Nos. 7-35, Inclusive, and 75 Per Cent of 6

See Table No. 31 and Plate 92

Item	Estimated Cost
Intercepting Sewers and Force Mains	\$ 2,801,000
Diversion Structures	80,000
5 Pumping Plants - Structures	217,000
5 " " - Equipment	144,000
Treatment Works - Structures	851,000
" " - Equipment	540,000
Outfall Pipe and Outlets	945,000
Land, Rights of Way, Miscellaneous Structures	160,000
TOTAL	\$ 5,738,000
Engineering and Contingencies - Add 20 per cent	1,148,000
TOTAL	\$ 6,886,000

NOTES: Population: 1940, 453,680; 1965, 632,400; 1990, 692,800

Estimated Dry Weather Sewage Flow, Millions of Gallons per 24 Hours:

1940, 29.6; 1965, 47.5; 1990, 53.8

Sizes and Lengths of:

Interceptors:	126,400 feet - 10" to 84"
Force Mains:	10,400 feet - 10" to 54"
Outfall:	13,400 feet - 72" to 90"

Type of Treatment: Settling, Grease Removal, Sludge Digestion, and Sludge Filtration.

Table No. 64

East Bay Cities Sewage Disposal Survey - 1941 Report

ESTIMATED ANNUAL COST OF PROJECT A FOR THE 20-YEAR PERIOD 1945-1965

RICHMOND: CASTRO POINT

To Serve Sewerage Districts Nos. X, Y, 1-5, Inclusive, and 25 Per Cent of 6

See Tables Nos. 31 and 40 and Plate 95

Item	:	Years					20-Year Averages
		1945	1950	1955	1960	1965	
Interest	:	46,900	41,100	35,200	29,300	23,500	35,200
Bond Retirement	:	39,100	39,100	39,100	39,100	39,100	39,100
Maintenance	:	8,000	8,000	8,000	8,000	8,000	8,000
Insurance	:	800	800	800	800	800	800
Services - Administrative	:	500	500	500	500	500	500
" - Operational	:	24,000	24,000	24,000	24,000	24,000	24,000
" - Miscellaneous	:	1,000	1,100	1,200	1,300	1,400	1,200
Power - Pumping - 3 Plants	:	8,000	9,400	10,500	11,500	12,500	10,400
" - Sewage Treatment	:	4,500	5,000	5,500	6,000	6,500	5,500
" - Miscellaneous	:	300	300	300	300	300	300
Supplies and Miscellaneous	:	5,300	5,300	5,300	5,300	5,300	5,300
TOTALS	:	138,400	134,600	130,400	126,100	121,900	130,300

NOTES: Estimated average dry weather flow in millions of gallons:

1945, 3.3; 1950, 4.8; 1955, 6.0; 1960, 7.3; 1965, 8.1

Interest taken at 3 per cent.

Retirement of 40-year serial bonds (to begin in 1945) taken in lieu of depreciation and as representing the general effective life of the project.

Maintenance, insurance, services, power, and miscellaneous supplies calculated in detail.

Type of Treatment: Settling, Grease Removal, Sludge Digestion, and Sludge Drying Beds.

Estimated Construction Cost, \$1,564,000.

Table No. 74

East Bay Cities Sewage Disposal Survey - 1941 Report

ESTIMATED ANNUAL COST OF PROJECT K FOR THE 20-YEAR PERIOD 1945-1965

OAKLAND: KEY SYSTEM PIER

To Serve Sewerage Districts Nos. 7-35, Inclusive, and 75 Per Cent of 6

See Tables Nos. 31 and 50 and Plate 98

Item	:	Years					20-Year Averages
		1945	1950	1955	1960	1965	
Interest		206,600	180,700	154,900	129,100	103,300	154,900
Bond Retirement		172,200	172,200	172,200	172,200	172,200	172,200
Maintenance		33,700	33,700	33,700	33,700	33,700	33,700
Insurance		1,800	1,800	1,800	1,800	1,800	1,800
Services - Administrative		3,800	3,800	3,800	3,800	3,800	3,800
" - Operational		55,700	55,700	55,700	55,700	55,700	55,700
" - Miscellaneous		5,000	5,000	5,000	5,000	5,000	5,000
Power - Pumping - 5 Plants		50,100	56,000	60,300	64,500	67,800	60,000
" - Sewage Treatment		15,200	15,900	16,600	17,300	18,000	16,600
" - Miscellaneous		700	700	700	700	700	700
Supplies - Miscellaneous		36,500	38,000	39,500	41,000	42,500	39,500
TOTALS		581,300	563,500	544,200	524,800	504,500	543,900

NOTES: Estimated average dry weather flow in millions of gallons:

1945, 33.7; 1950, 38.0; 1955, 41.6; 1960, 45.2; 1965, 47.5

Interest taken at 3 per cent.

Retirement of 40-year serial bonds (to begin 1945) taken in lieu of depreciation and as representing the general effective life of the project.

Maintenance, insurance, services, power, and miscellaneous supplies calculated in detail.

Type of Treatment: Settling, Grease Removal, Sludge Digestion, and Sludge Filtration.

Estimated Construction Cost, \$6,886,000.

Table No. 88

East Bay Cities Sewage Disposal Survey - 1941 Report

COMPARISON OF CONSTRUCTION COSTS
OF VARIOUS POSSIBLE COMBINATIONS OF PROJECTS AS INDICATED

For Comparison of Total Annual Costs See Table No. 89

Ref. No.	Project Combination	Estimated Total Construction Cost	Per Capita* Total Construction Cost	Total Construction Per 1000 Dollars Assessed Valuation**
1	A, K	8,450,000	16.10	18.88
2	A, Q, R	8,157,000	15.53	18.22
3	A, N, S	8,157,000	15.53	18.22
4	A, N, T ¹	8,434,000	15.53	18.62
5	A, E, I	8,900,000	16.95	19.89
6	A, G, M, S	8,485,000	16.16	18.95
7	B, K	9,198,000	17.52	20.55
8	A, N, R, X	8,378,000	15.95	18.72
9	A, N, U, X	8,741,000	16.65	19.54
10	A, E, L, S	8,521,000	16.23	19.04
11	A, E, O, R	8,619,000	16.42	19.26
12	A, G, J, X	9,072,000	17.29	20.28
13	A, G, M, T ¹	8,762,000	16.14	19.34
14	A, N, V, X ¹	8,899,000	16.39	19.64
15	A, E, H, X	9,093,000	17.32	20.32
16	A, E, L, T ¹	8,798,000	16.20	19.65
17	B, N, S	8,905,000	16.97	19.92
18	A, E, O, V ¹	9,140,000	16.83	20.18
19	A, G, M, R, X	8,706,000	16.58	19.45
20	A, G, M, U, X	9,069,000	17.27	20.27
21	A, E, L, R, X	8,742,000	16.64	19.51
22	B, N, T ¹	9,182,000	16.91	20.27
23	A, G, M, V, X ¹	9,227,000	16.99	20.37
24	A, E, L, U, X	9,105,000	17.35	20.37
25	A, E, L, V, X ¹	9,263,000	17.06	20.45
26	B, N, R, X	9,126,000	17.38	20.40
27	B, G, P, V ¹	9,857,000	18.15	21.76
28	C, D, I	10,898,000	20.76	24.35
29	C, F, M, S	10,397,000	19.80	23.23
30	C, F, J, X	10,984,000	20.94	24.58
31	C, F, M, T ¹	10,674,000	19.66	23.56
32	C, D, H, X	11,091,000	21.11	24.79
33	C, F, M, R, X	10,618,000	20.24	23.75
34	C, F, M, V, X ¹	11,139,000	20.51	24.59
35	C, D, L, V, X ¹	11,261,000	20.74	24.86

NOTES: 1. San Leandro is included in this project combination.

2. Based on 1945 population of 525,000 excluding, and 543,000 including, San Leandro.

3. Based on 1944-45 assessed valuation of 447.5 millions of dollars excluding, and 453.0 millions of dollars including, San Leandro.

Table No. 89

East Bay Cities Sewage Disposal Survey - 1941 Report

COMPARISON OF TOTAL ANNUAL COSTS
FOR VARIOUS COMBINATIONS OF PROJECTS AS INDICATED

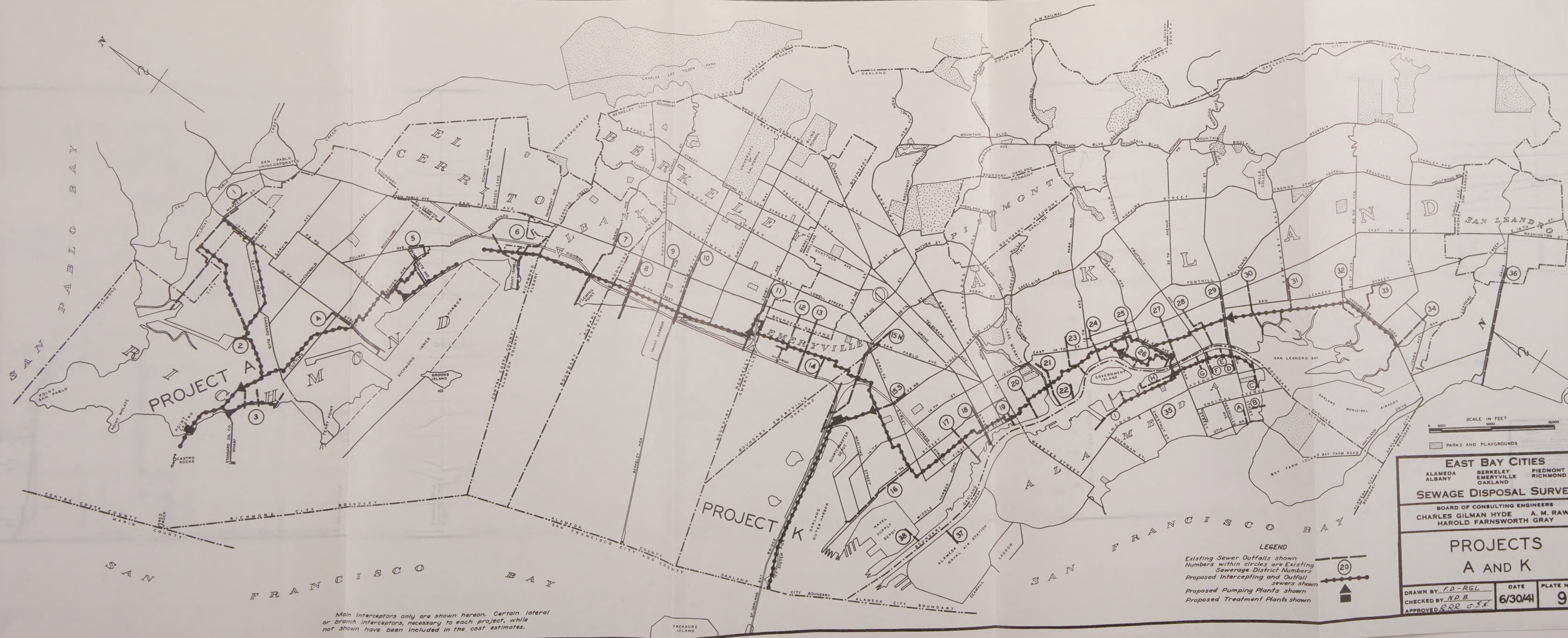
For Comparison of Construction Costs See Table No. 88

Ref. No.	Project Combination	20-Year Ave. Total Annual Cost ¹	Per Capita ² Total Annual Cost		Total Annual Cost ³ Per 1000 Dollars Assessed Valuation	
			1945	1965	1944-45	1964-65
1	A, K	674,200	1.37	.92	1.60	1.31
2	A, Q, R	706,400	1.43	.96	1.68	1.38
3	A, N, S	707,700	1.43	.97	1.68	1.38
4	A, N, T ¹	730,600	1.43	.96	1.71	1.41
5	A, E, I	738,100	1.50	1.00	1.76	1.44
6	A, G, M, S	745,100	1.51	1.02	1.77	1.46
7	B, K	751,800	1.51	1.04	1.77	1.48
8	A, N, R, X	753,400	1.52	1.03	1.78	1.48
9	A, N, U, X	759,600	1.54	1.03	1.80	1.48
10	A, E, L, S	762,300	1.54	1.04	1.81	1.49
11	A, E, O, R	766,800	1.56	1.05	1.82	1.50
12	A, G, J, X	767,700	1.56	1.05	1.82	1.50
13	A, G, M, T ¹	768,000	1.51	1.01	1.80	1.48
14	A, N, V, X	773,000	1.52	1.05	1.82	1.51
15	A, E, H, X	785,100	1.60	1.07	1.87	1.53
16	A, E, L, T ¹	785,200	1.54	1.03	1.84	1.51
17	B, N, S	785,300	1.57	1.08	1.85	1.55
18	A, E, O, V ¹	786,400	1.55	1.03	1.85	1.51
19	A, G, M, R, X	790,800	1.60	1.08	1.88	1.55
20	A, G, M, U, X	797,000	1.62	1.09	1.90	1.56
21	A, E, L, R, X	808,000	1.63	1.10	1.92	1.59
22	B, N, T ¹	808,200	1.57	1.08	1.88	1.58
23	A, G, M, V, X ¹	810,400	1.59	1.07	1.90	1.56
24	A, E, L, U, X	814,200	1.65	1.11	1.94	1.59
25	A, E, L, V, X ¹	827,600	1.63	1.09	1.94	1.60
26	B, N, R, X	831,000	1.66	1.15	1.95	1.65
27	B, G, P, V ¹	844,500	1.65	1.12	1.97	1.64
28	C, D, I	870,400	1.76	1.18	2.07	1.69
29	C, F, M, S	873,500	1.76	1.19	2.07	1.71
30	C, F, J, X	896,100	1.82	1.22	2.13	1.75
31	C, F, M, T ¹	896,400	1.76	1.18	2.10	1.73
32	C, D, H, X	917,400	1.86	1.25	2.18	1.80
33	C, F, M, R, X	919,200	1.86	1.26	2.18	1.80
34	C, F, M, V, X ¹	938,800	1.84	1.24	2.20	1.81
35	C, D, L, V, X ¹	959,900	1.88	1.26	2.25	1.85

NOTES: 1. Includes San Leandro.

2. Based on populations: 1945, 525,000; 1965, 682,000 excluding San Leandro, and 1945, 543,000; 1965, 707,000 including San Leandro.

3. Based on assessed valuations: 1944-45, 447.5; 1964-65, 476.5 millions of dollars excluding San Leandro, and 1944-45, 453.0; 1964-65, 483.0 millions of dollars including San Leandro.



Main interceptors only are shown hereon. Certain lateral or branch interceptors, necessary to each project, while not shown have been included in the cost estimates.

SCALE IN FEET
0 1000 2000 3000

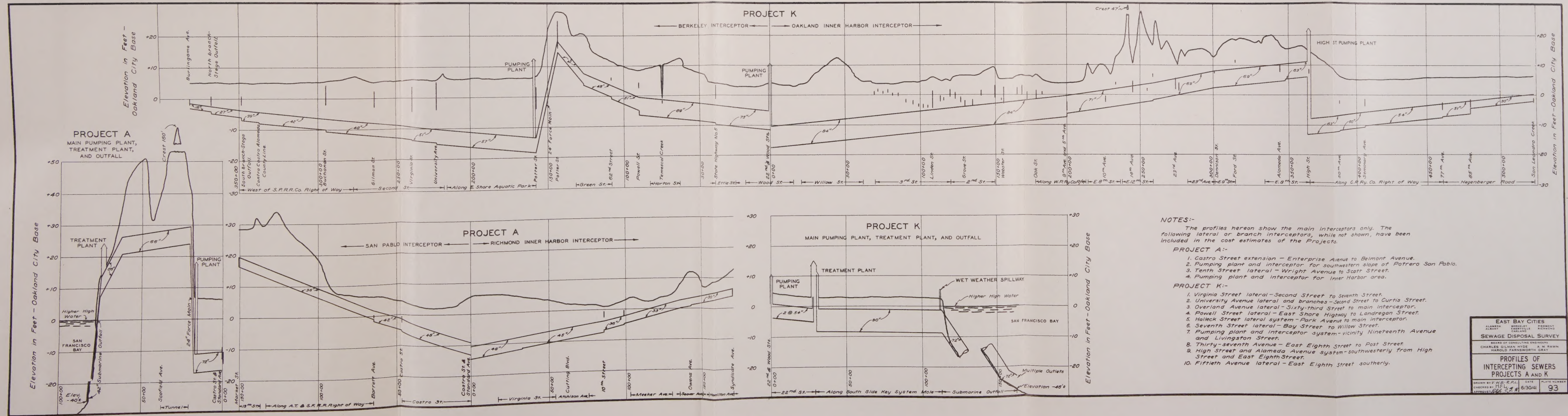
PARKS AND PLAYGROUNDS

EAST BAY CITIES
ALAMEDA BERKELEY PIEDMONT
ALBANY EMERYVILLE RICHMOND
SEWAGE DISPOSAL SURVEY
BOARD OF CONSULTING ENGINEERS
CHARLES GILMAN HYDE A. M. RAWN
HAROLD FARNSWORTH GRAY

**PROJECTS
A AND K**

DRAWN BY <u>F.D.-RGL</u>	DATE <u>6/30/41</u>	PLATE NUMBER <u>92</u>
CHECKED BY <u>N.D.B.</u>		
APPROVED <u>R.R.R. C.S.H.</u>		

LEGEND
Existing Sewer Outfalls shown
Numbers within circles are Existing
Sewerage District Numbers
Proposed Intercepting and Outfall
sewers shown
Proposed Pumping Plants shown
Proposed Treatment Plants shown



U.C. BERKELEY LIBRARIES



C104723096

